Civil engineering applications of scrap tires: An emerging market

By Dana Humphrey, Ph.D. and Michael Blumental

Using scrap tires to replace conventional construction materials is back on track after some setbacks.

Since its beginnings in the early 1990s, the use of scrap tires in civil engineering applications has had a roller coaster-like existence. Recently, new information has become available --information that should answer many of the doubts, concerns and uncertainties that previously limited the expansion of this market. This market for scrap tires now is poised to provide a myriad of possible uses that can consumer large quantities of scrap tires in a positive manner.

How are scrap tires used in civil engineering applications, and what are the possible benefits? A "civil engineering application" is the use of scrap tires in place of some conventional construction material such as clean fill, aggregate and rock. Scrap tires have been used as lightweight road embankment fill, backfill behind walls, insulation to limit frost penetration beneath roads, aggregate in leachate and gas collection systems in landfills, and the drainage bed for residential septic system. Scrap tires usually are shredded for use in these applications, with the actual size a function of the intended use. The required size can range from a refined two-inch or three-inch square shred to a coarser, three-by twelve-inch shred.

In defining the various uses for scrap tires, civil engineering applications generally are considered to be those that require a shred no smaller than two inches in any dimension. Applications for smaller-sized, scrap tire-derived material, such as the use of particulate rubber as a soil amendment, as a turf top dressing or as an additive to asphalt paving materials, are classified as ground rubber markets and are beyond the coverage of this article.

The defining characteristic of a civil engineering application is that the tire-derived material produces a cost-effective engineering benefit. In other words, civil engineering applications should not be used just to bury tires. The use of scrap tires in civil engineering applications is based upon the unique characteristics of tire shreds, namely lightweight, good insulation properties, very high ability to transmit water, good long-term durability and high compressibility. With these properties, engineers can use tire shreds to solve many of the construction problems that cause them to lie awake at night, and just as important, tire shreds can save their clients money. Not to mention, applications also can consume a very large quantity of scrap tires.

The market that almost wasn't

The first use of scrap tires in civil engineering applications can be traced back to the mid-1970's, when they were used to build breakwaters and artificial reefs. Few scrap tires were used in civil engineering applications between the mid-1970's and 1991, perhaps two to three hundred thousand. (In comparison, more than 240 million scrap tires were generated annually in the U.S.). By 1992, tire shreds were being used in road embankments and being tested as a lightweight backfill for walls. These uses were offered as alternatives to the federal mandate for the use of rubber-modified asphalt, but neither was readily accepted by the highway construction community.

The number of scrap tires going into civil engineering applications had increased to almost 10 million a year by the end of 1995. Estimates at that time about this market segment were that civil engineering applications would be consuming upwards of 15 million to 20 million scrap tires by 1997. Then came the burning roads.

In December 1995 and January 1996, reports about hot spots in two road bed embankments built with scrap tire fill in Washington state and one wall with scrap tire backfill in Colorado were announced to the world. At first, it was steam emanating from vents in the embankments. Soon, there were reports of glowing embers within the embankments. Finally, flames were shooting out of the fills. This news spread, pardon the expression, like wildfire. The impact of these events was dramatic, immediate and profound. In quick order, the majority of civil engineering applications for scrap tires came to an abrupt halt. In 1996, the only major use of scrap tires in civil engineering applications was in landfill construction and operation. The market shrunk to five million tires.

Questions and solutions

To address questions raised by the internal heating problem, the Scrap Tire Management Council (Washington), together with the Tire and Rubber Advisory Committee of the International Tire and Rubber Association (Louisville, Kentucky), convened an Ad hoc committee. Members were selected from the scrap tire industry, academia and the Federal Highway Administration (Washington). The committee reviewed design and construction characteristics from all previous similar projects, more than 70 in all. Except for the Washington State and Colorado incidences, none had experienced catastrophic heating failures. The committee compared several factors that could have contributed to the heating event. While the precise cause of the heating is still unknown, several factors were identified that appeared to increase the likelihood that a tire shred embankment would self-heat. The key factor appeared to be the large fill depth. The three problem sites all exceeded 25 feet in depth. The committee decided to take a conservative approach by minimizing the impact of any factor that could contribute to self-heating.

The committee drafted a document entitled *Design Guidelines To Minimize Internal Heating of Tire Shred Fills,* which, when completed, was accepted by FHWA. The guidelines then were distributed widely, including distribution by FFIWA regional offices. The guidelines recommend that the thickness of a tire shred layer be limited to three meters (I 0 feet) and that relatively large shreds with a minimum of rubber fines be used. Moreover, steps should be taken to limit the flow of air and water into the interior of tire-shred fills. The recommended guidelines supplied the information needed to allay most of the technical concerns that constrained this market segment. In addition, FHWAs approval and distribution increased the legitimacy and acceptance of these guidelines.

Just before these hot spot incidents, STMC and Dr. Dana Humphrey, of the University of Maine (Orono), had begun a project to develop standard engineering guidelines for scrap tires in civil engineering applications. This effort involved taking a draft proposal to Committee D34 of the American Society for Testing and Materials (West Conshohocken, Pennsylvania). After a three-and-one-half-year effort, there now is an ASTM *Standard Practice for Use of Scrap Tires in Civil Engineering Applications* (ASTM D 6270-98). The combination of the FHWA design guidelines and the ASTM Practice now provides the industry with the range of information necessary to further develop this market sector.

Field applications:

The jetport interchange success story

The Maine Turnpike Authority wanted to build a new interchange to provide better access to the Portland, Maine jetport. The problem was a thick layer of soft, gooey clay that underlaid the only available site. An embankment built with conventional soil would have been so heavy that it would have sunk into the clay. The designers for the project, HNTB, Haley & Aldrich, and Dr. Humphrey turned to tire shreds to solve the problem.

This project was designed in late 1996, so the draft recommendations to limit self-heating and the draft ASTM guidelines were available. To meet these guidelines, the designers chose to use two layers of lightweight tire shreds, each up to 10-feet thick, separated by a three-foot thick clay layer. To keep air and water out of the tire shreds, the sides and top of the embankment were covered by three to six feet of clay. A key to limiting embankment heating is large shreds with few fines, so the designers specified 12inch maximum shreds with no more than 1 percent by weight smaller than one-quarter of an inch. The tire shredders for the project, J.P. Routhier & Sons (Littleton, Massachusetts) and Arthur Schofield, Inc. (Lancaster, Massachusetts) put in extra effort to provide tire shreds meeting these requirements.

It takes more than good engineering to make happen projects such as the Jetport Interchange. MTA had two choices to procure the tire shreds. One was to buy them on the open market, which meant that about two-thirds of the cost of shredding the tires would come from the tipping fee paid to the tire shredder for taking in the whole tires. The other option was to get the whole tires from an abandoned stockpile. This was particularly attractive, since Maine has 30 million to 60 million tires scattered around the state. To make this latter option happen, MTA and the Maine Department of Environmental Protection, with HNTB acting as mediator, negotiated an agreement where MTA would pay about one-third of the shredding cost and MDEP would pay the balance. Thus, the price paid by MTA was the same as if it had purchased the tires on the open market.

In the end, everyone was a winner. MTA saved $300,000 over the cost of the next cheapest construction alternative (expanded polystyrene insulation board). Moreover, the subsidy provided by MDEP was $300,000 less than would have been paid to shred the same tires for tire-derived fuel. Finally, the citizens of Maine were winners by having 1.2 million tires removed from an abandoned stockpile.

Tire shreds save landfill

In another case, three communities in northern Maine constructed an expansion to their jointly owned Tri-Community Landfill. Within a few months of completion, landfill officials knew they had a problem. The limestone-derived sand that was supposed to be the drainage layer at the bottom of the landfill had hardened into a concrete-like mass. Rather than acting as a drainage layer, the sand was now a semi-impervious barrier. MDEP regulators refused to issue a final permit until the problem with the drain was fixed. Little did anyone realize that the solution was a pile of 300,000 scrap tires stockpiled at the landfill.

Arthur Schofield, Inc., working in partnership with Humphrey, proposed that the tires be cut into three- to 12-inch pieces for use as a supplemental drainage layer at the bottom of the landfill. Landfill owners and state regulators jumped at the idea. For years, the on-site scrap tire pile had been a bone of contention, with regulators pressuring the landfill owners to remove the pile. The owners balked at the high cost - the closest licensed tire disposal facility was some 400 miles away, which pushed the disposal cost to $110 per ton. Using tire shreds in the landfill would both solve the drainage problem and get rid of the troublesome pile of tires. Arthur Schofield, Inc. set up a portable tire shredder and worked well into Maine's cold winter to produce the tire shreds needed for the job. In the New England tradition of helping one's neighbors, the landfill owners sent word to all the communities in northern Maine telling them that they could take their tires to Tri-Community Landfill for only the cost of shredding (about $80 per ton). At the end of the project everyone was smiling. The landfill owners solved their drainage problem at a cost far less than they expected. Moreover, the communities in northern Maine cleaned up all their scrap tires for 25 percent less than shipping them downstate.

Projections for the future

Successful projects, such as the Portland Jetport Interchange and Tri-Community Land**fill,** are expected to jump-start the market for civil engineering applications of scrap tires. Moreover, the ASTM guidelines, along with the recommendations to limit self-heating, will provide engineers with the information they need to use tire shreds in future projects. From the end of 1997 through the middle of 1998, an estimated 18 million to 20 million scrap tires were used in this market segment. The only question now is how high can this market go?

The Scrap Tire Management Council can be reached at (202) 682-4882, (202) 682-4854 (fax).

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